

Supplied by U.S. Dept. of Agriculture
National Center for Agricultural
Utilization Research, Peoria, Illinois

Sensory and Nutritional Evaluations of Oatrim^{1,2}

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ABSTRACT

Effects of the substitution of oatrim for fat on the sensory characteristics of cookies and candy were investigated. Shortening in oatmeal raisin cookies was replaced with oatrim gel at 50, 75, and 100% levels. The cookies were evaluated by a 20-member sensory panel. The cookie with a 50% level of substitution was not significantly different ($P > 0.05$) for flavor and texture characteristics from the control cookie, but at 75 and 100% levels of substitution, differences were observed. Substituting oatrim gel for whipping cream in reduced-fat truffle centers caused no significant flavor intensities changes at the 50% level compared with the control. At a 100% level of substitution, there was a significant ($P < 0.05$) reduction in the creamy/buttery flavor compared with the control. To confirm that oatrim exhibited the hypocholesterolemic properties associated with oat products, a nutritional evaluation of oatrim in chicks showed a very significant reduction in total and low-density lipoprotein cholesterol levels.

Oatrim, a fat substitute, was discovered (1,2) and patented (3) by the U.S. Department of Agriculture with licenses granted to ConAgra, Quaker Oats, and Rhone-Poulenc. The process involved the α -amylase conversion of starch in the oat flour or bran to amylo-dextrins. The product, which is a concentrated, purified, water-soluble, and nearly tasteless white powder consisting of soluble β -glucan and amylo-dextrins from the oat flour, was referred to as

oat β -glucan-amylo-dextrins or oatrim. Barley and other cereal grains were used to prepare barleytrim and other amylo-dextrins containing soluble fibers (4).

Oatrim forms a fat-like gel that has one calorie per gram compared to nine calories per gram for fat (5). Oatrim and its gel are heat stable in food applications such as processed meats, pasteurized cheeses, and baked products including breads, cookies, muffins, brownies, and cakes. Currently, oatrim is used commercially in extra lean ground beef, franks, bologna, fat-free cheeses, cookies, granola bars, and muffins (6).

Oats have been recognized to be effective in lowering serum cholesterol since 1963 (7). A recent meta analysis of several studies has shown the efficacy of oats as a hypocholesterolemic agent in humans (8). The effectiveness is dependent on consuming a sufficient quantity of oatmeal or oat bran over an extended period of time. Although the sensory evaluation of oatrim is more directly related to its practical use, its nutritional function as an oat product was evaluated to make certain that the enzymatic processing did not decrease its hypocholesterolemic property.

Oatrim can be easily incorporated into commonly consumed foods, such as meats, dairy, and baked items. Its wide potential for food applications makes possible sustainable consumption of oats. This study was conducted to deter-

mine if oatrim affected the sensory properties of foods in which it was used to modify fat content and to confirm that oatrim processing did not decrease the hypocholesterolemic properties associated with oat products.

MATERIALS AND METHODS

Oatrim-5 was obtained from A. E. Staley Manufacturing Company (Decatur, IL). The reported composition and properties include: moisture, 4.0–8.0%; ash, 2.0–3.0%; fat (ether extraction), 0.5% maximum; protein ($N \times 6.25$), 5.0% maximum; pH (10% solution), 5.5–6.5; dextrose equivalent (DE), 3.0–5.0; β -glucan, 4.5–5.5; and gel strength, 10–14 mm.

Preparation and Sensory Evaluation of Cookies

Oatmeal raisin cookies prepared from a commercial bakery recipe were selected to study shortening replacement with oatrim. The formulation required the creaming of granulated sugar (4 lb), brown sugar (9 lb), salt (5.5 oz), baking soda (3 oz), extra fine sugar (1 lb), and margarine (9 lb). To this blend, the following ingredients were mixed in: rolled oats (14 lb), cake flour (7 lb), all-purpose flour (2 lb), raisins (12 lb), and eggs (2.13 lb). The yield was about 60 lb of cookies. Oatrim and water were substituted for 50, 75, and 100% of the margarine.

Table I. Fat and Oatrim Quantities Used to Prepare Oat Raisin Cookies

Component	Quantity
Control	9 lb fat in 60-lb formula ^a
50% oatrim	1.13 lb oatrim 3.37 lb water 4.5 lb fat
75% oatrim	1.69 lb oatrim 5.06 lb water 2.25 lb fat
100% oatrim	2.25 lb oatrim 6.75 lb water

^a Makes 60-lb of cookies per batch.

¹ Adapted from a paper presented at the 78th AACC Annual Meeting, October 1993.

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Sweet	0	1	2	3	4	5	6	7	8	9	10
	none		weak		moderate		strong				

Fig. 1. An example of the type of scale used to evaluate flavor and texture.

Table II. Proximate and Fiber Content of Diet Components (Percent Dry Matter)

Component	Protein	Fat	Starch	IDF ^a	SDF ^b	TDF ^c
Cornmeal	9.54	3.98	67.5	9.66	0.33	9.99
Casein	90.81
Oatrim	10.22	1.91	53.6	0.56	8.63	9.20

^aInsoluble dietary fiber.

^bSoluble dietary fiber.

^cTotal dietary fiber.

Oatrim was added as a dry powder, and the water was the only liquid added to complete the recipe. No modifications were made to control differences in moisture loss during baking. The formulations for cookies using margarine or oatrim and water are shown in Table I.

A sensory panel with 20 members trained and experienced in testing cereal-based products evaluated the oatmeal raisin cookies for the following flavor characteristics: sweet, grainy, toasted, buttery, and cardboardy. They also evaluated the texture properties of density, cohesiveness, and moistness. Figure 1 represents the type of scale used to evaluate the flavor and texture. Judges also rated the cookies for overall quality. The control sample of cookies (no substitution) was rated in preliminary blind sensory tests.

Table III. Composition of Diets Fed to Chicks (Percent Dry Matter)

Ingredient	Control	Oatrim
Cornmeal	63.66	29.35
Casein	18.64	17.96
Oatrim		38.04
Cornstarch	3.82	
Dicalcium phosphate	2.80	2.80
Calcium carbonate	1.50	1.50
Vitamin mix	1.00	1.00
Salt	0.50	0.50
Trace mineral mix	0.15	0.15
DL-Methionine	0.30	0.16
Antibiotic	0.10	0.10
Biotin	0.01	0.01
Soybean oil	6.97	7.60
Cholesterol	0.50	0.50
Total protein, %	23.00	23.00
Total fat, %	10.00	10.00
Total dietary fiber, %	6.36	6.36
Calories (kcal/kg)	3,699	3,348

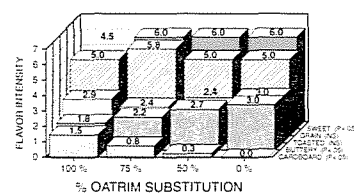


Fig. 2. Flavor characteristics of oat raisin cookies prepared by replacing margarine with oatrim at levels of 0, 50, 75, and 100%. Flavor rated on a scale of 0-10 where 0 = none and 10 = strong. LSD = 1.0.

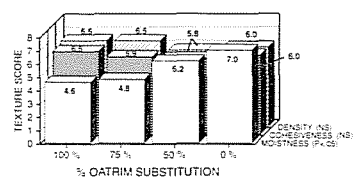


Fig. 3. Texture characteristics of oat raisin cookies prepared by replacing margarine with oatrim at levels of 0, 50, 75, and 100%. Density, cohesiveness, and moisture rated on scales of 0-10 where 0 = light, 10 = compact; 0 = crumbly, 10 = gummy; and 0 = dry, 10 = wet, respectively. LSD = 1.0.

Preparation and Sensory Evaluation of Reduced-Fat Chocolate Truffles

Chocolate truffles were selected to study the effects of replacing their whipping cream fat centers with oatrim gel. To prepare a 10-lb batch containing 25% whipping cream, finely chopped milk chocolate (7.5 lb) was placed in a small pan and whipping cream (20 oz) was heated to boiling in a separate pan and poured over the chocolate. After standing 3–4 min, the mixture was stirred until smooth and glossy and then cooled in a refrigerator for 15 min. Rounded teaspoonfuls of the center mixture were formed into balls, covered with chocolate, and chilled.

An oatrim gel containing 30% solids was substituted on a volume basis for 50 and 100% of the whipping cream. A 50% oatrim gel substitution required 30% oatrim gel (10 oz) and whipping cream (10 oz) heated as previously described. The 100% oatrim gel substitution required the complete elimination of cream, adding only the gel (20 oz). The oatrim gel was prepared by blending 30% oatrim with 70% water and heating to boiling before allowing it to gel in the refrigerator overnight.

A 20-member sensory panel evaluated the chocolate truffles for the following flavors: bitter, creamy/buttery, chocolate, and sweet. They also evaluated the texture properties of smoothness, chewiness, and density. The control sample of truffles was also rated in preliminary blind sensory tests.

Oatrim Hypocholesterolemic Property in Chicks

In a larger followup study to confirm an earlier report on hypocholesterolemic properties of oatrim (9), 48-day-old

broiler chicks were fed a basal corn and casein diet containing vitamins, minerals, and 0.50% cholesterol for one week to make them hypercholesterolemic. Oatrim and other major diet components were analyzed for protein (Kjeldahl $N \times 6.25$), fat (10), starch (11), and dietary fiber (12). Chicks were wing-banded with identification numbers and divided into three groups of eight chicks for each diet treatment. The basal diet was continued as a control for 24 chicks, and the remainder were placed on a diet containing 38% oatrim. Tables II and III contain proximate and fiber content of major diet components and composition of the chick diets, respectively. Chicks were fed diets for 14 days and then fasted overnight and were weighed. Blood samples were drawn and plasma was analyzed for total cholesterol, triglyceride, and high-density lipoprotein (HDL) cholesterol on a Kodak DT 60 analyzer (Eastman Kodak, Rochester, NY). Plasma low-density lipoprotein (LDL) cholesterol was calculated as described by Friedwald and coworkers (13).

RESULTS AND DISCUSSION

Sensory Evaluation of Cookies

Results of the evaluation of fat substitution by oatrim revealed that graininess and toasted flavor intensities were not significantly affected by the addition of oatrim to the cookies (Fig. 2). Cookies with 100% oatrim substitution of fat had significantly ($P < 0.05$) less sweet taste and buttery flavor and significantly ($P < 0.05$) more cardboard flavor than did the unsubstituted sample. The texture characteristics of density and cohesiveness were not significantly changed by the addition of oatrim (Fig. 3); however,

moistness of the cookies containing 75 or 100% oatrim substitution of fat was significantly ($P < 0.05$) less than that for the 0% oatrim sample.

Overall quality of the cookies was not significantly changed by the use of 50% oatrim substitution of fat (Fig. 4); however, the quality of the cookies containing either 75 or 100% oatrim substitution was lower ($P < 0.05$) than was that of the 0% oatrim cookie.

Sensory Evaluation of Reduced-Fat Chocolate Truffles

Only the 100% substitution of oatrim for fat affected the creamy/buttery flavor characteristics by significantly ($P < 0.05$) decreasing its flavor compared to the 0% and the 50% oatrim samples (Fig. 5). The 50% oatrim substitution of fat caused no significant changes in flavor intensities compared to the unsubstituted sample.

The chewiness and density texture characteristics were not significantly affected by oatrim substitution for fat in the truffles (Fig. 6). The grittiness levels of samples with the 100 and 50% oatrim substitutions of fat were significantly ($P < 0.05$) higher than they were in the 0% oatrim truffle.

Because some textural changes were noted in the sensory evaluation, the surfaces of the different truffle centers were examined by scanning electron microscopy (SEM). Samples of the truffle centers were mounted on aluminum stubs, coated with a layer of gold-palladium (60:40) alloy, and then examined and photographed in a JEOL model JSM 6400V scanning electron microscope. The surface areas of the truffle centers at 500- μ m resolution show some differences in the surface areas. The pictures cannot be related to mouthfeel, but they do indicate that differences in the truffle matrix can be observed (Fig. 7). The oatrim truffle surfaces appear to have some larger particle areas. This is probably not unexpected in view of the large chemical differences between the fat and oatrim.

Oatrim provides an easy way to replace fat and increase soluble content in many foods, especially meats, dairy, and bakery goods where it has found considerable commercial use. This study on fat substitution by oatrim in oatmeal raisin cookies and chocolate truffles was done to establish some guidelines for oatrim usage as evaluated by sensory evaluation. The study was not an attempt to find optimum product or conditions for producing such foods. The results indicate that oatrim can readily replace 50% of the fat in these products tested. It would be expected that greater oatrim replacement could be made, but product formulation changes would be necessary.

Hypocholesterolemic Property of Oatrim

A pilot study to test the hypocholesterolemic property of oatrim was con-

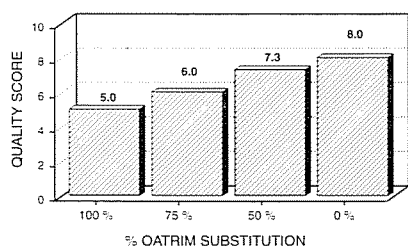


Fig. 4. Overall quality rating of oat raisin cookies prepared by replacing margarine with oatrim at levels of 0, 50, 75, and 100%. Quality rated on a scale of 0–10 where 0 = bad and 10 = excellent. LSD = 0.8.

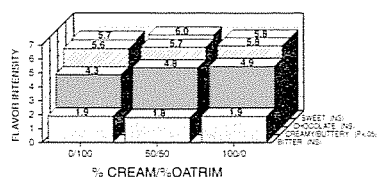


Fig. 5. Flavor characteristics of truffles prepared by replacing whipping cream with oatrim at levels of 0, 50, and 100%. Flavor rated on scale of 0–10 where 0 = none and 10 = strong. LSD = 0.5.

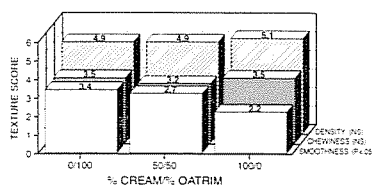


Fig. 6. Texture characteristics of truffles prepared by replacing whipping cream with oatrim at levels of 0, 50, and 100%. Density, chewiness, and smoothness rated on scales of 0–10 where 0 = smooth, 10 = gritty; 0 = soft, 10 = hard; and 0 = crumbly, 10 = dense, respectively. LSD = 0.7.

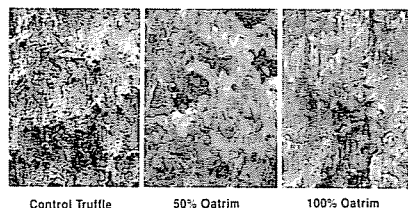


Fig. 7. Surface area at 500 μ m of truffle centers prepared by replacing whipping cream with oatrim at levels of 0, 50, and 100%.

Table IV. Feed Consumption, Body Weight and Feed/Gain Ratios of Chicks Fed Oatrim or Control Diets

Diet	Feed Consumed (g)	Weight Gain (g)	Feed/Gain Ratio
Oatrim	1976	562 A ^a	3.54 A
Control	2196	905 B	2.44 B

^a Within each column, data followed by a different letter are significantly different for weight gain ($P < 0.0009$) and for feed/gain ratio ($P < 0.01$).

Table V. Blood Plasma Lipids of Chicks Fed Oatrim or Control Diets (mg/dl)

Diet	n	Plasma Cholesterol ^a			Triglycerides
		Total	HDL	LDL	
Oatrim	24	239 A ^b	123	99 A	84
Control	24	400 B	131	251 B	87

^a HDL = high-density lipoprotein; LDL = low-density lipoprotein.

^b Within each column, data followed by a different letter are significantly different ($P < 0.0001$).

ducted earlier at Montana State University (9). This study includes a larger followup study to confirm the earlier results. Chicks fed oatrim gained significantly less body weight than the controls, and there was a significant difference in feed/gain ratio between the two groups (Table IV). This is a typical response when chicks are fed diets high in soluble fiber and is usually accompanied by a corresponding fecal excretion of fat (14). Chicks fed oatrim had highly significantly lower ($P < 0.0001$) total and LDL cholesterol than did controls (Table V). There were no differences in HDL cholesterol or triglycerides between the two groups. This experiment provides further evidence for the healthful beneficial character of oatrim and confirms that oatrim processing does not decrease its hypocholesterolemic properties.

CONCLUSIONS

Oatrim can replace shortening in oatmeal raisin cookies at levels of 50, 75, and 100%. According to sensory evaluation, the cookie with the 50% shortening substitution was not significantly different ($P < 0.05$) in flavor and texture characteristics from the control cookie. In making reduced-fat truffle centers, oatrim gel can be substituted for whipping cream without causing significant flavor intensities at the 50% cream level. At 100% substitution, there was a significant reduction in the creamy/buttery flavor and increased graininess. The hypocholesterolemic property of oatrim in chicks, with a significant reduction in total blood cholesterol and LDL cholesterol levels, suggests that oatrim could have a health benefit in foods.

Acknowledgments

We thank F. L. Baker (scanning electron microscopy), Terry C. Nelsen (statistical analysis), and Mary Kinney and Julie Musselman (technical assistance). Samples of TrimChoice-5 brand oatrim were provided by Steve Grisamore

of Mountain Lake Manufacturing Company, Omaha, NE, and Tom Doxsie, A. E. Staley Manufacturing Co., Decatur, IL.

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